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Franklin M. Turrell
State University of Iowa

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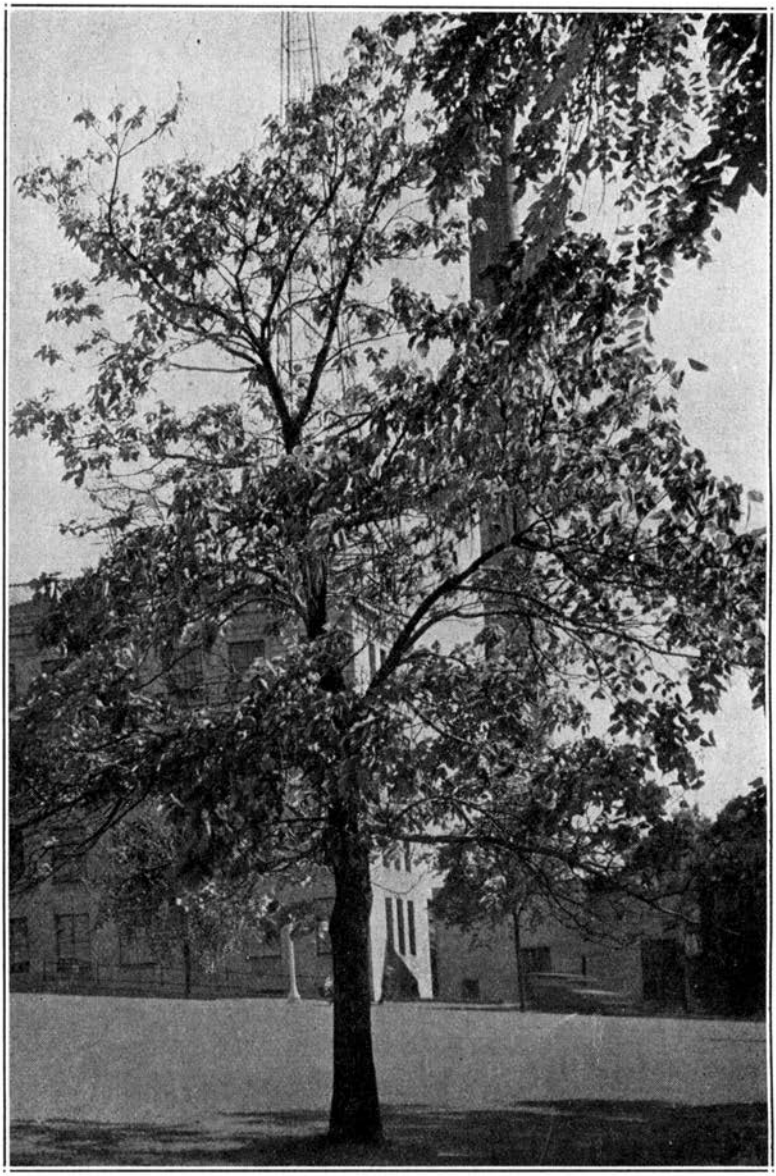
FRANKLIN M. TURRELL

Opportunity for leaf count and area measurement of the foliage of an entire tree was afforded when on August 25, 1933 a catalpa (*Catalpa speciosa*) was felled on the west side of the Old Capitol on the University of Iowa Campus (Plate I). The tree was located seventy-six feet southeast of the intersection of the east walk of Madison Street and Iowa Avenue. It stood on an open lawn near the base of a long five percent slope, removed more than 150 feet from any large trees on the east or south, therefore receiving direct sunlight throughout the morning and early afternoon. A double oak forty-eight feet high was located fifty-seven feet to the southwest and shaded the catalpa from late afternoon sun. A vigorous elm seventy-six feet high stood eighty feet to the northwest.

The catalpa (*Catalpa speciosa*) was twenty-one years old, as determined by annual ring count, had a diameter at base of seventeen inches and a height of approximately thirty-three feet as determined later from a photograph. It was fruiting and in fair condition, having one large dead branch in the crown. This and the fact that small trees of better promise were to replace it probably supplied reason for its being cut down.

REVIEW OF LITERATURE

Höhnel (1) showed that fifty to sixty year old forest beeches had 35,000 leaves while an isolated birch had 200,000 leaves. Groom (2) measured the surface of young conifers of the same age and found that *Picea excelsa* had a surface of 1.4 square meters, *Abies pectinata* 1.2 square meters, and *Pinus sylvestris* 0.5 square meter. Ramann (3) found that a dominant beech about fourteen meters tall had 10,950 leaves with a total leaf surface of 24.45 square meters. Knuchel (4) counted 119,000 leaves from a beech thirty-seven centimeters in diameter; total surface was 142.5 square meters. Spruce and silver fir forty centimeters in diameter bore ten to twenty million needles. Those sixty to seventy centimeters in diameter bore thirty to forty million needles. A spruce



EXPLANATION OF PLATE

Catalpa speciosa from which leaves were taken for measurement and count; Madison Street and Iowa Avenue, University of Iowa Campus. Photograph by Kent, October, 1929.

with twenty million needles had a calculated surface of 351 square meters. Büsgen (5) found in four-year-old spruces, 6,577 needles totaling an area of .055 square meter per tree.

Methods

Immediately after the tree was felled the tip ends of the branches, bearing leaves, were broken off and thrown in piles on the lawn. These were immediately removed in baskets to the laboratory, where they were kept moist until measured. Small leaves were finally raked up and the debris sifted until all leaves were removed. As no other catalpas grew on this plot no extraneous leaves of the species were present to invalidate the count.

The leaves were separated into five groups on the basis of blade length. This was accomplished by measuring each leaf against one of five scales marking the maximum for each group size. The intervals used for these groupings were: group 1, 4.1 — 9 cm.; group 2, 9.1 — 14 cm.; group 3, 14.1 — 19 cm.; group 4, 19.1 — 24 cm.; group 5, 24.1 — 29 cm. As the leaves were measured they were placed in group-piles.

As leaves were counted they were immediately destroyed to avoid error. No leaf blade was counted unless the petiole was attached. Petioles were counted though no blade was attached (the group being readily determined by the relative petiole size which was closely correlated with blade length). Only minor errors occurred because of this procedure since there were few mutilated leaves. Counting was completed while the leaves were fresh and pliable.

Ten leaves were selected at random from each of the five groups. These were blue printed and the prints measured by planimeter. Statistical methods as outlined by Bailey (6) were applied to these samples to establish the correlation between blade length and area.

In the measurement of major vein area a pressed leaf was selected from each group. The length of the major veins was found by direct measurement with Paragon chain scale. Diameters of the bases of the veins were measured with a microscope fitted with ocular micrometer. From these dimensions calculations of leaf area interrupted by the major veins of each sample leaf were made.

Measurement of minor veins was made on cleared, preserved, chlorophyll-extracted leaves, using a microscope fitted with ocular micrometer. Vein diameters were measured exclusive of border parenchyma and the intervascular intervals, from xylem center to xylem center.

RESULTS

Table I. Characteristics of leaf population

	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	TOTALS
Blade length	4.1-9 cm.	9.1-14 cm.	14.1-19 cm.	19.1-24 cm.	24.1-29 cm.	
Number	10,790	9,133	4,697	1,400	22	26,024
Mean area of ten blades in sq. cm.	29.38	70.68	137.20	242.41	378.34	
Class area in sq. cm.	317,010	645,520	642,158	339,374	8323	1,952,385
% major vein area per blade	4.96	4.50	4.00	4.40	3.50	9.23 *
% major vein area per blade	4.57	----	----	----	5.36	
$\frac{\text{Internal Exposed Surface}}{\text{External Surface}}$	----	----	14.36	----	----	$\frac{5.1\text{x}10^7 \text{ cm.}^2}{3.9\text{x}10^6 \text{ cm.}^2}$
Number of stomata	----	----	----	----	----	$1.6\text{x}10^9$

* Average used in making total.

In the measurement of the internally exposed surface, the method used was that outlined by the author in an article now filed for early publication in Iowa Natural History Studies. The method is based essentially upon camera-lucida drawings of transverse and tangential (7) leaf sections which are measured with planimeter and chartometer.

The number of stomata per unit area of leaf surface was determined from camera-lucida drawings of the epidermis of a group 3 leaf, and served as a basis for calculating stomatal number for the leaf population.

Discussion

In this study it was necessary to group leaves on the basis of blade length and establish a high positive correlation between blade length and area so that measurement of area in a few samples could be used as the basis for calculating total leaf area. A statistical analysis of the ten samples from each class gave a correlation coefficient (r) of $+.98$, the probable error (E_r) being $\pm .0035$. As $r = 280\ E_r$ we may conclude that the areas given in the five classes shown in table I represent reasonably well the mean areas since whenever $r > \pm 4E_r$ significance may be attached to r, (8).

The exposure of wet cell walls to the atmosphere has long been known to be indispensible for the necessary gases, oxygen and carbon dioxide, in gaseous exchanges (9). Application of methods described above show, (a) that the external heavily cutinized leaf area which forms the upper leaf surface for the whole tree totals 1,952,000 square centimeters (Table I); (b) that the veins interrupt 9.23 percent or 180,000 square centimeters of this area; and (c) that approximately 1,772,000 square centimeters cover chlorenchymatous tissue. The under side of the leaf which is slightly cutinized also totals 1,772,000 square centimeters of exposed area (not including veins). The total external surface of the leaf, not including vein area for the two surfaces, is therefore 3,540,000 square centimeters. The lower leaf surface, however, is perforated by stomata which connect with intercellular spaces upon which the moist walls of the chlorenchyma cells are exposed. This internal area bordering the intercellular spaces is 14.4 times[1] (Table I) the area of the external leaf surface (minus veins) and equals 51,000,000 square centimeters (Table I), 5,100 square meters, or 1.27 acres. If the external surface (not including veins) is added to the internal exposed surface the total is 1.35 acres.

The risk of exposing this tremendous surface to the drying air

1 Based on class 3 leaf.

is not as great as would at first appear (10), for if all of the one and a half billion stomata close completely only 6.5 percent of the total surface is left exposed.

Without doubt larger surfaces can be expected in vigorous trees, and application of the recent method described by Gerdel and Salter (11) will make possible easier application of statistical methods with attending more accurate results. Other methods are reviewed extensively by Vyvyan and Eveans (12).

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LITERATURE CITED

1. Höhnel, V. Ueber die transpiration grössen der forstlichen Holzgewächse, Mitteil. aus dem forstl. Versuchswesen Öesterreichs, Bd. *2*, Heft 1. 1880.
2. Groom, P. Remarks on the Oecology of Coniferae. Annals of Botany *24*:241-269, 1910.
3. Ramann, E. Blättergewicht und Blattflächen einiger Buchen. Zeitschrift fur Forst und Jagdwesen 43. 1911.
4. Knuchel, H. Spektrophotometrische Untersuchungen im Walde. Mitteil d. Schweiz. Zentralanstalt f.d. forstl. Versuchwesen *9*:87. 1914.
5. Büsgen, M. and Münch, E. The structure and life of forest trees. Trans. by T. Thompson, John Wiley and Sons, New York, p. 200. 1931.
6. Bailey, L. and Gilbert, A. Plant Breeding. P. 41-51, 149-154, 399-420, Macmillan Co., New York. 1930.
7. Haberlandt, G. Physiological Plant Antomy. Trans. by M. Drummond, Macmillan and Company, London, p. 282. 1928.
8. Babcock, E. and Clausen, R. Genetics in Relation to Agriculture McGraw Hill Co., New York, p. 179. 1927.
9. Barnes, C. The significance of transpiration. Science n.s. *15*:460. 1902.
10. Turrell, F. Internal Exposed Surface of Foliage Leaves. Science, *78*:536-537. 1933.
11. Gerdel, R. and Salter, R. Measurements of leaf area using the photoelectric cell. Journ. Amer. Soc. Agron. *20*:635-643. 1928.
12. Vyvyan, M. and Eveans, H. The leaf relations of fruit trees. Jour. of Pomol. and Hort. Sci. *10*: 228-270. 1932.

Department of Botany,
State University of Iowa,
Iowa City, Iowa.